Influence of freezing and thawing conditons at initial age to the strength development of mortars

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1 Introduction

Agricultural water usage, as the world's largest form of water use, accounts for 70% of total water use and is a critical component of the social water cycle; however, even in areas with sufficient water supplies, agricultural water demand cannot be fully met.

Agricultural irrigation canals are widespread across Japan and extensively used in productive farming. There is an urgent need to extend the service life of these facilities to reduce their maintenance cost. Ordinary portland cement concrete has a range of benefits, including low costs, high compressive strengths, and flexibility in fabrication and casting, but its durability concerns are gaining more attention these days, as the majority of concrete structures are experiencing performance degradation. Concrete performance is affected by a variety of factors, including material composition, curing schemes and temperatures, hazard species, harsh conditions, and external loads.

Therefore, the purpose of this study is to experimentally explore the effect of low-temperature history on the long-term strength of polymer cement mortar, especially during the early stage of the mortar's life, thus, 3 days of age. In this study, two types of polymer cement mortar were used: powdered ordinary polymer cement mortar and powdered fast-hardening polymer cement mortar, thus 100P and 100PS respectively.

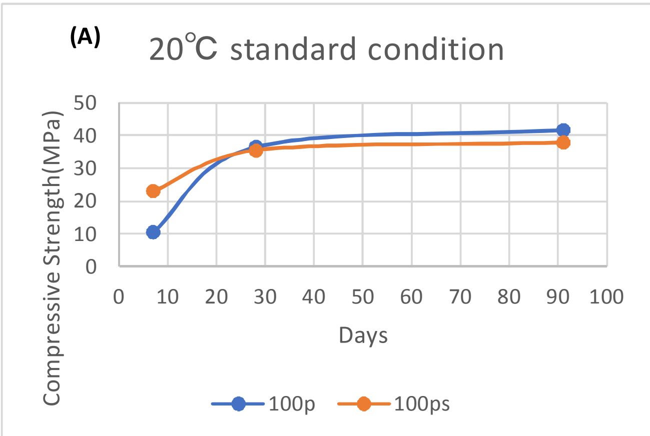
2 Methodology

For the current study, a total of 90 mortal specimens were prepared, which was subsequently subdivided in into two, thus based on the properties of cement mortar used. The water-cement ratio was the value recommended by the manufacturer, and tap water was used for mixing. All mortar specimens were prepared by hand-kneading using a Makita UT1305 cement mixer machine. A 4kg of each polymer cement mortar, thus 100PS and 100P was measured using the electronic balance and was well-mixed with water in a bucket and later transferred into the plamold cases.

The curing conditions of mortar specimens were all standard water curing after 3 days of material age except for intentional temperature change, and an incubator capable of providing arbitrary low-temperature history was used to provide history up to 3 days of material age. Since the volume of the mortar was observed to expand with time, the top of the filled plamold case was sealed with plastic immediately after casting and the top load was applied to prevent any change from the predetermined volume.

In this experiment, the temperature history of the specimens during curing was set at 20°C (hereinafter referred to as control), which was recommended by the manufacturer, as the standard condition, and all other mortar specimens were subjected to low-temperature history immediately after curing. The reason why the minimum value of the low temperature was set to -10°C was that it is the lowest temperature in cold regions in Japan, and the maximum value of the temperature history was set to +5°C based on the assumed daily difference.

Furthermore, the temperature was repeatedly changed between -10°C and +5°C for 12 hours, 6 hours, and 3 hours respectively. The age of the specimens was set at 7 days, 28 days, and 91 days.



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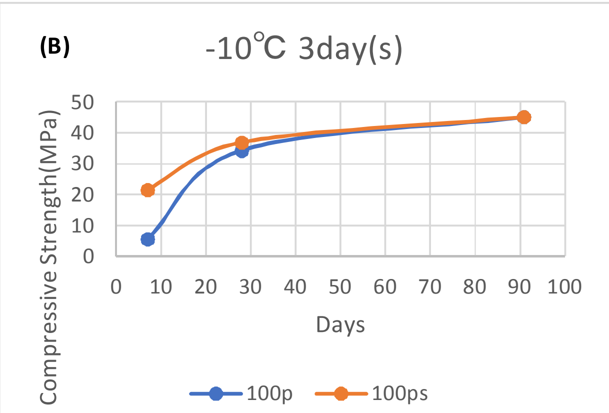
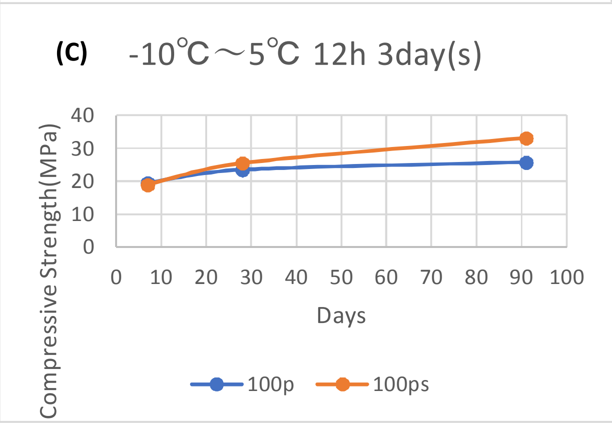
Key words: Compressive strength, Polymer cement mortar, concrete, Irrigation canal

The test results were basically the average of the three specimens.

3 Results and Discussion

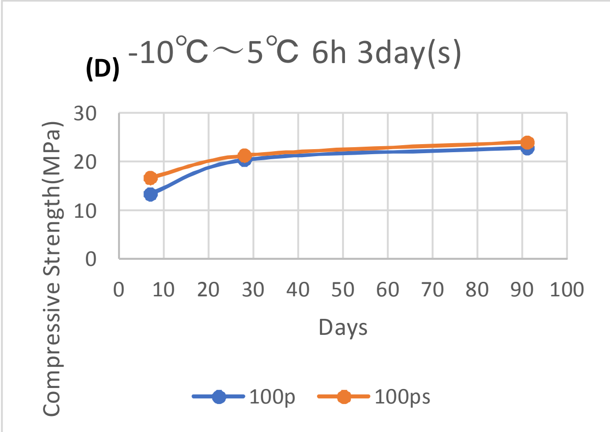
It was confirmed that 100PS, which is a fast curing type, has a larger initial strength development rate. The experimental results indicate that the compressive strength analysis of the polymer cement mortar is lower than the standard cured, whenever the initial curing process was subjected to rapid temperature changes (-10℃ to 5℃) every 3 hours as shown in Fig 2A and Fig 2E; subsequently, its purpose of extending the service life of agricultural canals cannot be fulfilled. We again noted that the compressive strength of the specimens subjected to low temperature during the initial curing period does not show positive strength on the 91st day, and depending on the timing of the repair work, the waterway may lack sufficient compressive strength. However, under a constant low-temperature environment where freezing and thawing do not occur (-10 ℃), the fast-setting polymer cement mortar shows sufficient strength up

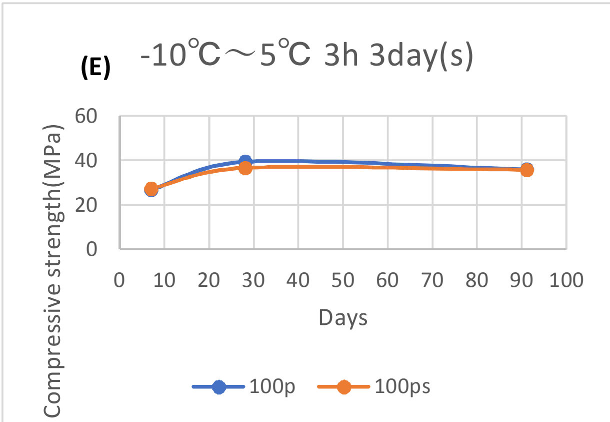




to 91 days recording an average of 45.1 MPa as shown in Fig 2B.

It was also confirmed that the freezing and thawing effect during the initial age of the specimens had a negative effect on the compressive strength. This suggests that the compressive strength of the





specimens was not sufficient due to the increase in the volume of water in the specimens caused by freezing and the destruction of the hardened parts by fine cracks due to the hydration reaction.

4 Conclusion

The decrease in compressive strength at 91 days was caused by freeze-thaw action more times than the specimens with 12-hour and 6-hour pitches, indicating that freeze-thaw action after casting has a negative effect on long-term strength development, even for the mortars subjected to this study.

The results from this work will provide a reference to experimentally clarify the effect of low-temperature history on the long-term compressive strength of typical polymer cement morta